Plastic Packaging recycling

Ambitious recycling objectives call for new approaches

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1. Context

Recycling targets adopted by Directive (EU) 2018/852 commit the Member States to take the necessary measures to achieve a recycling rate of 50% by December 31st, 2025, and at the end of 2030, 55% by weight of plastic from all packaging. Businesses shall be responsible under an extended producer responsibility regime to collect and recover non-household packaging wastes and ensure to meet those recycling objectives. Luxembourg has tabled on August 25th corresponding the bill of law to transpose the EU Directive into national legislation.

Non-household plastic packaging contains a large amount of plastic that is not or only difficult to recycle. This makes it challenging for businesses to reach their recycling objectives.

This paper sheds light on those challenges, proposes solutions and the industry's requirements to contribute to the 2025 and 2030 plastic packaging recycling objectives successfully.

2. Increasing the share of effectively recyclable plastic packaging materials

It is not a coincidence that plastic became one of the most popular packaging materials across many different sectors. Compared to alternative materials such as paper, glass, metal and even wood, plastic is often the most energy efficient to manufacture; it is lighter to transport and more versatile in use. With these characteristics, plastic packaging has a better carbon footprint in many applications compared to alternative materials. Unfortunately, the focus on plastics' end of life management tends to fall short of acknowledging the benefits it generates throughout its entire life cycle.

The most commonly used plastic materials for consumer and industrial packaging applications are[1]:

1. Polyethylen therphtahalat (PET)
2. High-density polyethylene (HDPE)
3. Polypropylene (PP)
4. Low-density polyethylene (LDPE)
5. Polystyrene (PS)
6. Polyvinyl Chloride (PVC)

[1] We could not identify a comprehensive and accurate study about the volumes or percentages of those materials when used as packaging in the EU, as such, the order of enumeration does not suggest a ranking.

All these six most popular materials used for packaging are recyclable, even though there are significant differences in the recycling technologies and costs depending on the material.

Just because a material can be recycled does not mean it will be recycled. LDPE is a good example. As a polyethylene-based thermoplastic, technically, LDPE can be recycled. It is used in plastic bags, like grocery bags. However, these LDPE bags tend to tangle in recycling machinery, making them difficult to handle, costly and thus challenging and unattractive to recycle mechanically.

The reality is that recyclers focus on the most cost-efficient recyclable materials: PET, HDPE, and PP. It is safe to assume that recycling those three materials currently contributes most to the overall EU plastic packaging recycling rates of 42%. In contrast, the other three materials' contribution (LDPE, PS, and PVC) to achieving those recycling rates is most likely negligible, mainly when recycling needs to be within the EU. They are usually incinerated or dumped into landfills.

The plastics industry is aware of this unbalance between recyclable and not recycled materials. Therefore, it is increasingly switching materials to the most cost-effectively recyclable materials with the lowest environmental impacts wherever possible.

Nevertheless, today we accept that the share of post-consumed, effectively recyclable plastic packaging materials, i.e. PET, HDPE, and PP is much lower than the overall volumes put on the market. There are three main reasons why significant volumes of those recyclable plastic packaging are not collected and brought back into recycling channels:

1. Composite materials: It is safe to assume that a non-negligible share of the recyclable plastic is processed into composite materials, making them nearly impossible to recycle. Composites are, for example, multi-plastics products created by mixing recyclable with non-recyclable plastics or multi-material products created by mixing recyclable and non-recyclable plastics with metals, dyes, additives or other chemical agents. Often those multi-material composites are laminated into multiple thin layers in packaging wraps. The thinner the packaging product, the more difficult it is to separate recyclable plastics from their non-recyclable counterparts. Thin-film composite material recycling is most often impossible by sorting and mechanical recycling technologies.
2. Contamination: Even if recyclable as a material, post-consumer plastics may not be suitable for reuse in their same original channel or suitable for reuse at all because of material contamination. Such contamination may occur either during its functionalization into a product, for example, by colouring the plastic or during its use, where contamination with organic materials is not uncommon. Often, plastics are incurably contaminated so that they cannot be brought back into recycling channels.
3. Quality: Recyclable plastics are not endlessly recyclable. Every time plastic is recycled, its polymer chains grow shorter, decreasing its quality. The same piece of plastic can only be recycled so many times before its quality declines to the point where it can no longer be used for recycling.

The latest progress in recycling technologies, i.e. better sorting and washing, but also innovative chemical recycling technologies, open new routes that may increase the share of recyclable plastics. In particular, chemical recycling is promising to overcome some of the most pressing difficulties listed above. The promotion and accreditation of those technologies to contribute to EU recycling targets could thus significantly improve plastic recycling rates (see Chapter 4).

3. Changing reporting rules endanger ambitious targets

In its press release of October 6th, 2020, the Luxembourg-based European Court of Auditors states that "there is a significant risk that the EU will not meet its plastic packaging recycling targets for 2025 and 2030." The press release[2] refers to a report analysing the EU's ambitions to increase its plastics packaging recycling and the feasibility of the EU to meet its own commitments. It warns that Member States should not underestimate the scale of their challenge in meeting the set recycling targets for plastic packaging. Current recycling rates in EU Member States are estimated to be inaccurately reported. The newly set reporting rules are likely to lead to a significant drop of the current rates at 42%, down to near 30%.

Another risk of missing the ambitious recycling target is the new agreement under the Basel Convention, restricting the export of plastic waste to non-EU countries beginning in 2021. Until then, nearly 30% of the EU's reported plastic packaging recycling rate was achieved through shipments to non-EU countries for recycling. The export ban is shifting those 30% back onto Member States as an additional recycling burden while EU recycling capacities have never been designed to meet such volumes. The missing plastics waste treating capacity within the EU constitutes another risk not to achieve the new targets.

4. Advanced recycling capacities and new accounting methods needed

Limitations of traditional recycling methods

Traditional plastic recycling methods, e.g. mechanical recycling, is limited to a narrow range of plastic packaging such as PET, HDPE, and PP. It mechanically sorts and crushes packaging material and remelts it into granulate. This granulate is then used to make new plastic products. The limitations of mechanical recycling are obvious; plastics that cannot be cost-effectively sorted, crushed and remelted are not recycled. As described in chapter 2, only three out of the six most popular plastic materials used for packaging today in the EU are recyclable because the recycling of the other plastic materials is either technically not feasible or economically not attractive.

Further, according to the European Food Safety Authority, granulates from mechanical recycling cannot be used in food packaging. This is because the granulates could contain hazardous substances for health, and they might penetrate the food. PET for bottles collected from a deposit system is the only exception.

Another challenge is the colour of the recycled plastic: When plastic waste is shredded and remelted into granulate, the resulting product is black-grey. Plastic products with brilliant colours can only be produced if shredded plastic flakes are sorted according to brightness. In addition, the granules made from recycled plastic often have an unpleasant smell, again unless the flakes are hot water washed.

Chemical recycling as a possible solution

Many of those limitations, including the narrow list of easily recyclable plastics, could be overcome by considering emerging new recycling technologies. Chemical recycling may be one possible route to explore. Chemical recycling splits polymer chains and supplies products such as crude oil, naphtha, or fuels from which new plastics of all sorts can be produced. Thus, chemical recycling could address recycling plastic waste that cannot be mechanically recycled for technical or economic reasons. It may also offer a solution for plastic waste, which is either contaminated or mixed and consists of multi-materials.

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[2] https://www.eca.europa.eu/en/Pages/DocItem.aspx?did=55223

Therefore, chemical recycling may be a complementary solution to traditional mechanical recycling, as it could be used to process a broader scope of plastic waste that is currently unsuitable for mechanical recycling. Additionally, chemical recycling can overcome some of the quality challenges faced by mechanical recycling as it can produce the basic chemicals needed to create high-quality food-grade packaging. It, therefore, also may overcome issues related to odour, colour, limited functionality in terms of application, and quality of the recycled content. Recycled content from chemical recycling is comparable to virgin materials and is likely to be integrated into food-grade packaging. Compared with traditional recycling, there is no down-cycling as the polymer bonds are renewed, meaning the plastics can be infinitely recycled.

Chemical recycling could thus represent a solution for plastic converters to meet recycling targets. In addition, it could help avoid incinerating or dumping plastics into landfills that are difficult to recycle by traditional methods. Recent announcements about increasing planned investments into chemical recycling, from 2.6 billion Euros in 2025 to 7.2 billion Euros in 2030 shows the industrial community's expectations into the technology[3].

The latest research[4] about chemical recycling's environmental performance tends to support the investor's expectations. Its findings show that the life cycle environmental impact of reconverting mixed plastic waste (MPW) by pyrolysis to new chemical feedstock emits 50% less CO2 eq. than energy recovery, i.e. incineration. Furthermore, the analysis suggests that MPW recycled by pyrolysis has a significantly lower climate change impact (–0.45 vs 1.89 t CO2 eq./t plastic) than the equivalent made from virgin fossil resources.

An argument often presented against further exploring chemical plastic recycling is its higher energy intensity than mechanical recycling. However, this argument is difficult to defend considering the very high material and energy efficiencies of chemical recycling. With a conversion rate of more than 99% of the collected plastic material, nearly all plastic turns into a valuable new product. Further, chemical recycling plants are designed to reuse their hot excess gases as energy input besides electricity, which is being rapidly decarbonised due to the ETS constraints. Research[5] underpins those arguments showing that the climate change impact and energy use of pyrolysis and mechanical recycling of mixed plastic waste are similar.

However, the technology is still immature, and its readiness level depends on the materials to be recycled. While chemical recycling seems to be near the industrial scale for some plastics, it is still at the lab scale for others[5]. Also, the European chemical recycling capacity can be estimated at a single-digit percentage, and the related technologies still need development.

A first step to accelerate impact analysis, technology developments, and capacity extensions could be a European-wide accepted accounting method for recycled volumes originating from chemical recycling. Countries like the Netherlands or the UK already accept feedstock today from chemical recycling as secondary raw materials. Clear definitions about which materials coming from chemical plastic recycling will be accepted in terms of contribution to the EU recycling objectives is necessary. The European Coalition on Chemical Recycling suggests defining chemical recycling "as converting polymeric waste by changing its chemical structure to produce substances used as products or as raw materials for manufacturing products". It excludes products used as

[3] European plastics manufacturers plan 7.2 billion Euros of investment in chemical recycling, PlasticsEurope press release, May 26th, 2021

[4] Jeswania H. et al, 2021: Life cycle environmental impacts of chemical recycling via pyrolysis of mixed plastic waste in comparison with mechanical recycling and energy recovery. Science of The Total Environment, Vol769, 15 May 2021, 144483

[5] Tullo, H. Alexander (2019): Plastic has a problem; is chemical recycling the solution? Chemical & Engineering News, Vol.97, Issue 39

fuels or means to generate energy.

5. Conclusion

Reaching the ambitious recycling objectives for plastic packaging set by the EU Commission for 2025 and 2030 calls for adaptive measures in multiple areas.

Some measures are as straightforward as educating users of plastic packaging to increase collection and recycling rates, avoid feedstock contamination, and improve manual sorting at the time of disposal. Others require a more coordinated effort across all the Member States, ideally harmonized by the EU Commission to preserve a level playing field for all stakeholders:

- Improve material standardisation of packaging to improve recyclability. Introducing standards in different areas of plastic packaging could help reduce the so-called "non-recyclable recyclables". Those are recyclable materials but, due to black colouring, for example, become non-recyclable. The same is true for challenging to remove labels that make recyclable packaging non-recyclable. As an example, the following standards in designing packaging could contribute to improving recycling rates:
  - The type of material used for packaging according to sectors and applications
  - Types of colouring and dye used
  - Types of labels and stickers used
  - Ease of separating plastics from other materials in a packaging product
  - Types of plastics used in a mix
- Promote investments in innovative recycling technologies such as chemical recycling to complement mechanical recycling for materials that are difficult to recycle, for example, thin films and multi-materials. Many of these technologies have been demonstrated at the laboratory scale. As a result, several companies are now scaling up to the commercial level, but it is not a short-term solution. However, its development and investment influx can be accelerated considerably if the EU Commission would acknowledge feedstock from chemical recycling as recycled material.

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